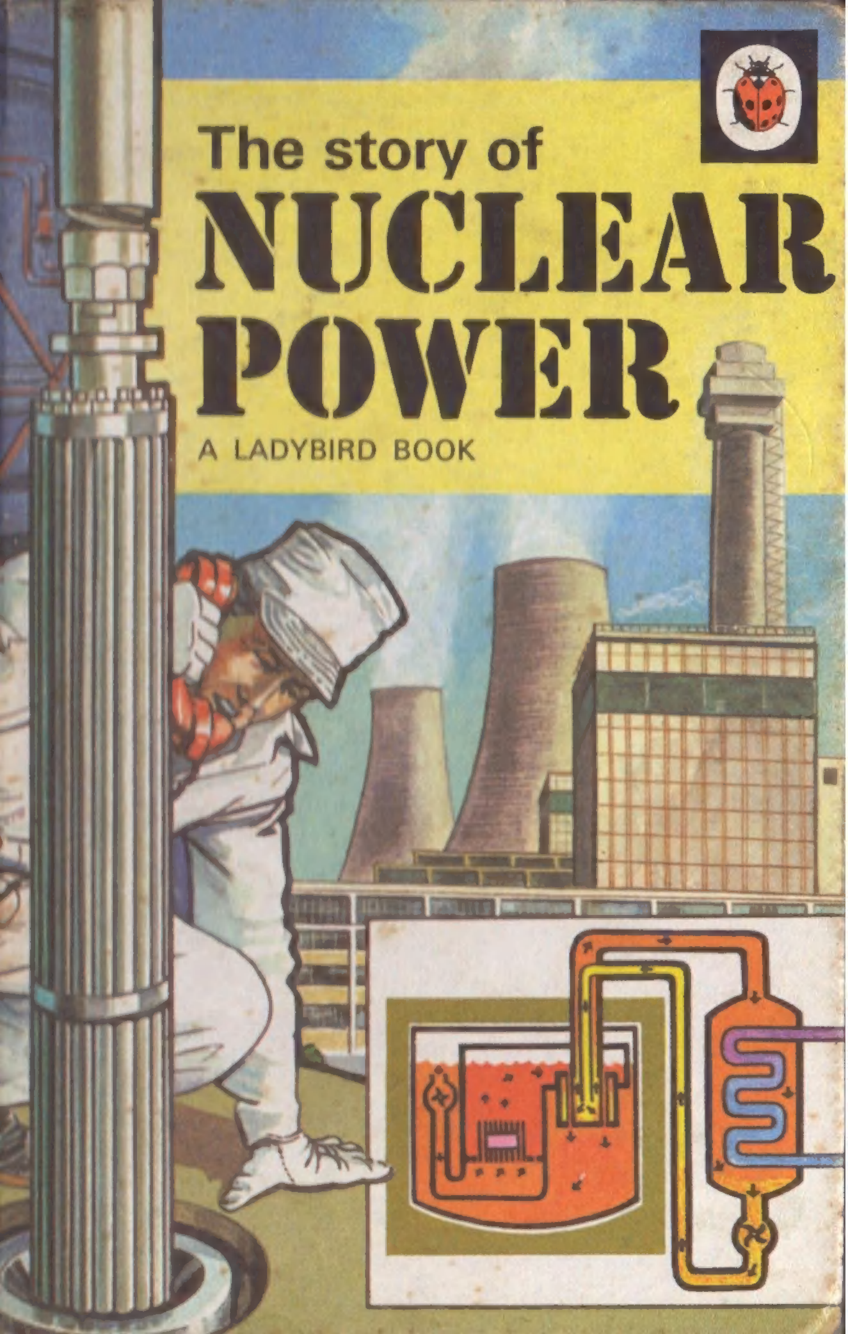

The story of
NUCLEAR
POWER
A LADYBIRD BOOK

A Ladybird
Achievements Book
Series 601

As our supplies of fossil fuels (oil, coal and natural gas) become used up, our power-hungry world will depend more and more on nuclear energy.

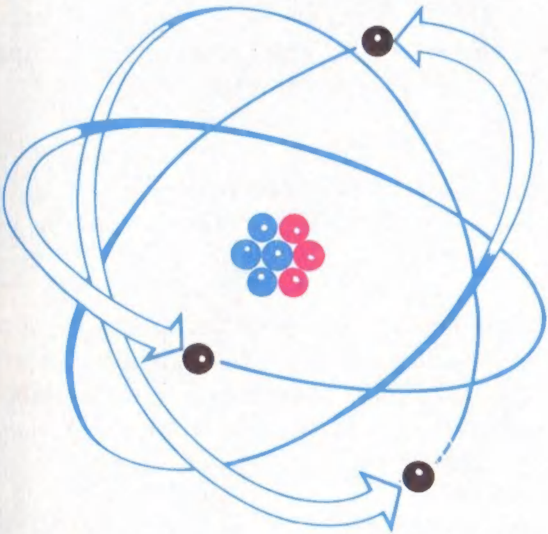
This book tells the story of this latest source of power—how it was discovered and how it is being developed.

Contents

THE STORY OF

NUCLEAR POWER

by E. H. CHILDS, M.B.C.S., A.M.I.E.E.
with illustrations
by ROBERT AYTON



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The need for nuclear power

A tremendous amount of power in one form or another is required to enable life, as we know it, to continue. In our homes we need power for heating, lighting, cooking, radio, T.V., and all sorts of other appliances. Industry uses huge amounts of power in the making of motor cars, aircraft, ships and countless other products.

Most of this power is provided by hydro power or the fossil fuels, that is—coal, oil and gas. Any additional means of producing power economically is welcome, particularly for generating electricity, as this frees the fossil fuels for many other industrial uses. Also, if enough power were made available, the living standards of people all over the world could be greatly improved.

Nuclear energy is another source of large quantities of power and is well suited for the generation of electricity.

Fusion, or the joining together of atomic matter, is a nuclear process which could give virtually limitless power, but so far it has evaded man's efforts to tame it. Nevertheless, another form of nuclear power, known as *fission*, the *splitting* of atomic matter, is now available.

This book is mainly about the wonderful progress in man's knowledge of the fission process, and its contribution towards nuclear power.

Power in the home

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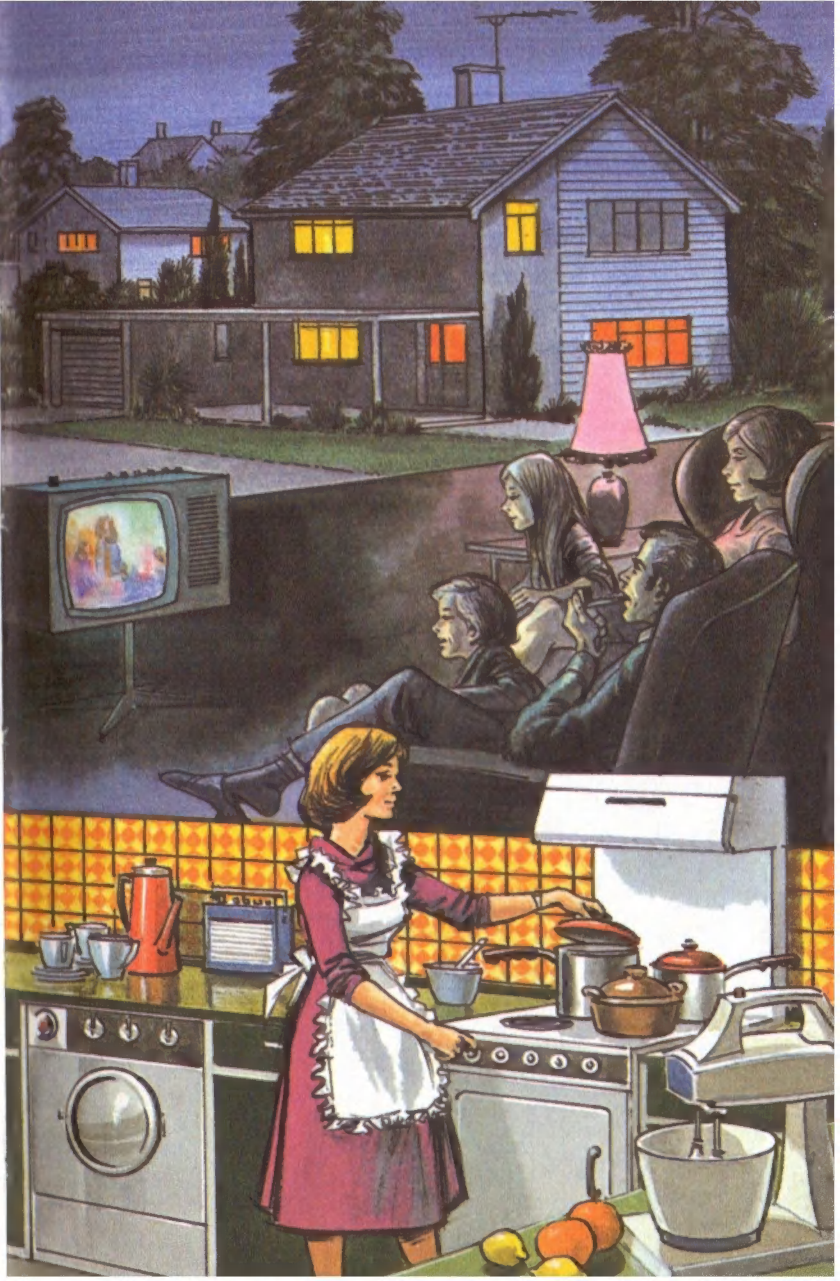


In the beginning

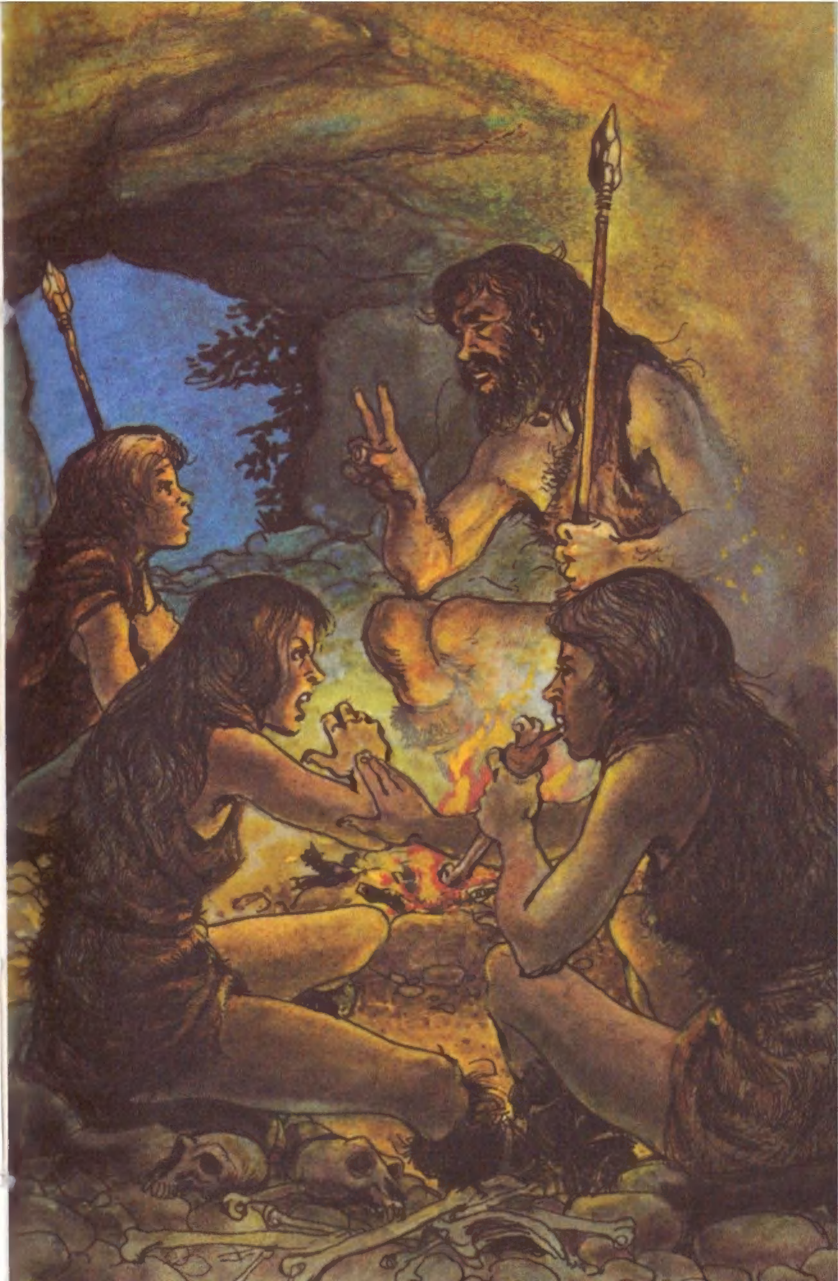
The element *uranium* is the fuel used when obtaining nuclear power by the fission process. Before man could produce power from this element he had to find the answers to many previously unanswered questions.

He could see the sun and the stars, and think 'How big is big?', or even wonder 'What is the smallest thing that exists?' The Greeks had a word for their idea of the smallest thing; the word was 'atomos', and it meant 'not cuttable'. We today use the word *atom* to describe these basic 'building blocks' of nature.

When man first used wood to light his fires, and even as he progressed to using the fossil fuels to produce power, he was only using forces that exist in the outer regions of the atom.

It was not until the twentieth century, after much research and experiment, that scientists could start thinking afresh and wondering if there was anything even smaller than the atom. Their discoveries led to the use of the much greater forces that can be released *from within the centre*, or nucleus, of the atom. This is what we mean by *nuclear power*.

Early man's source of heat – the wood fire – used only the forces that exist in the outer regions of the atom



A start is made

As far back as the fifth century B.C., Greek intellectuals, in particular Democritus, thought that everything must be made up of something basic, such as an atom. Nevertheless, for centuries afterwards the learned men of the times preferred to believe in other theories. One such theory was that fire, water, air and earth were the basic elements of the universe. In fact, it was not until the seventeenth century that the Englishmen, Francis Bacon, Robert Boyle and Isaac Newton made the atom idea of Democritus more popular.

Unfortunately, other new, and wrong, ideas were being considered at the beginning of the eighteenth century, and these temporarily shifted man's thoughts away from the possibility of the atom. *Phlogiston* became the 'magic' substance to explain anything which did not fit the known scientific facts of the time.

However, towards the end of that century the Frenchman, Lavoisier, and others started to experiment and distinguish between elements and compounds. Then the Englishman, John Dalton, worked out his atom theory, and the Italians, Avogadro and Cannizzaro started the scientists of the nineteenth century thinking more about the atom.

During an experiment in 1895, a German Professor, Röntgen, discovered some rays which he called X-rays. A year later a French scientist, Henri Becquerel, showed that similar rays were being emitted naturally from uranium salts. From then on the search for the elusive atom accelerated.

 Democritus explains his ideas about the atom

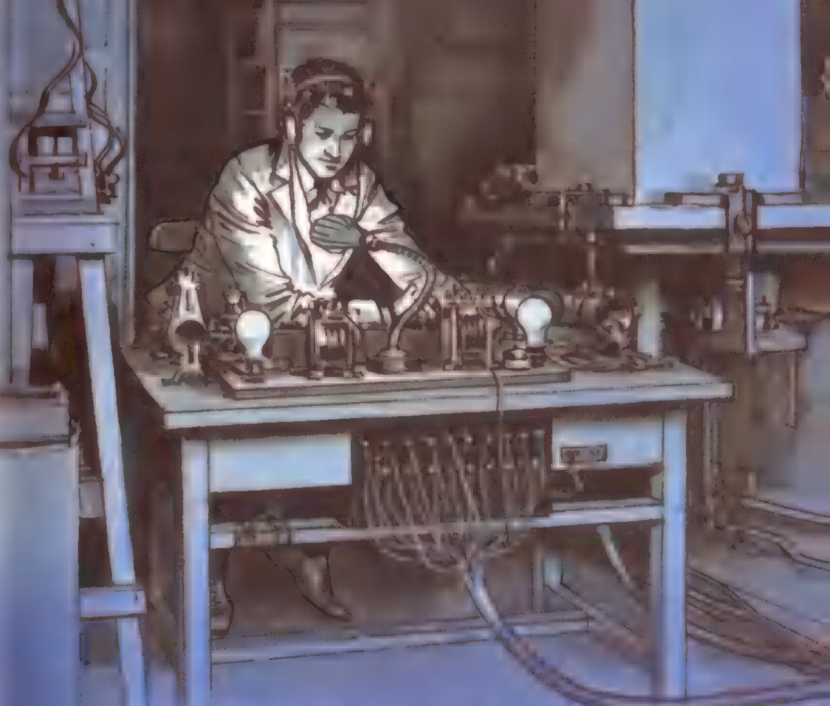
Fission

During the twentieth century, scientists from many countries helped to unravel the secrets of the atom. In 1905, Albert Einstein mathematically showed us that if lots of atoms of 'anything' were torn or split apart, a great amount of energy would be released.

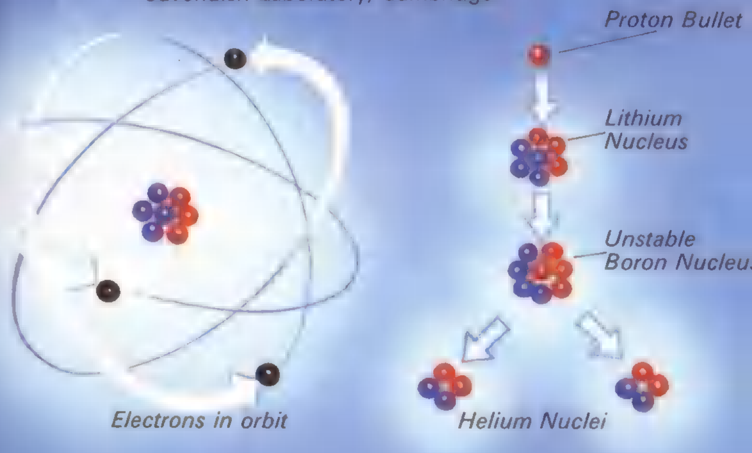
In 1919, Rutherford was the first scientist to split the atom artificially. He was followed by his colleagues, Cockcroft and Walton, who used an electric field accelerator (an 'atom smasher') for the first time in 1932. That year also saw the recognition of a new particle called the *neutron* which normally exists in the atom nucleus. Later on, very big electric field accelerators were built and used in experiments.

Various ideas on the structure of the imaginary atom were developed, including a model by Niels Bohr, in which a nucleus was surrounded by electrons. The nucleus consists of relatively heavy particles called protons and neutrons, whereas the surrounding electrons have virtually no weight at all.

The first real clue that the splitting of the atom could become useful was in 1939, when German physicists discovered that atoms of uranium could be split by bombarding them with neutrons, thereby creating great heat energy, also releasing further neutrons. This led to a new means of producing power—the *fission process*—in which the splitting of the atom is known as *fission*. The continuation of fission is referred to as a *chain reaction*.



Dr. John Cockcroft at work in the Cavendish Laboratory, Cambridge



A Lithium Atom — Split by Cockcroft and Walton

The fission process

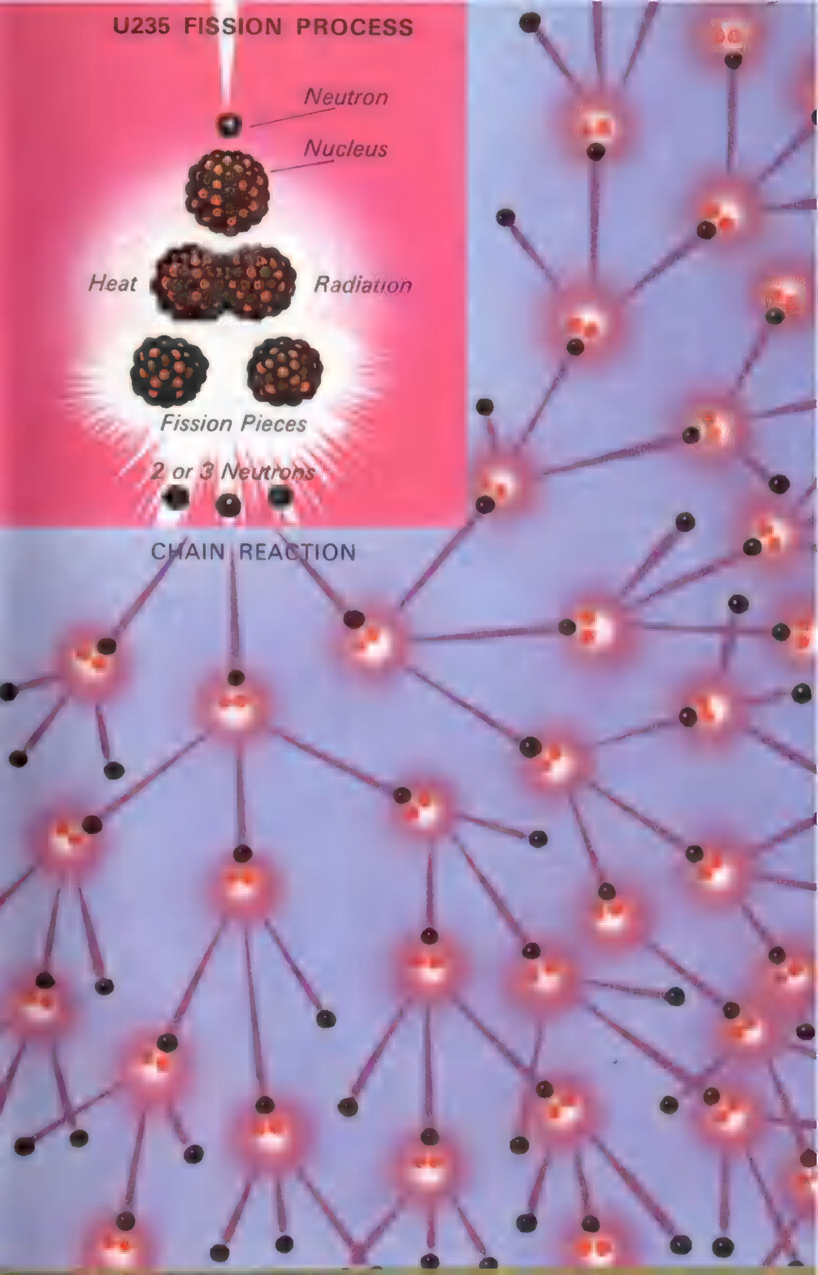
Scientists wondered whether the power inside the atom nucleus could be continuously released using this new process, but they still did not know how to achieve this. They knew that by bombarding uranium with neutron particles, the nucleus of the atom could be split into two pieces. These pieces moved apart at very high speeds, this process producing energy in the form of heat.

Two other forms of energy are given off when fission occurs. One is the radiation of very penetrating rays which can harm human tissues and cells. The other is the energy given to the extra neutrons that are released.

It was hoped that these very fast-travelling neutrons would produce fissions in other atoms, and so produce a chain reaction which could keep the process going. However, it was soon realised that at that time a sustained fission process could not be obtained by using uranium metal that had been processed from the mined ore. This 'natural uranium' metal consists of a very small part, called U.235, which is fissionable, and one hundred and forty times as much of another called U.238, which is not easily fissionable. So the scientists had either to extract the U.235 metal—a huge and very costly task, or they had to find a method of producing and maintaining fission in the natural uranium.

Both of these problems were soon solved.

The Uranium 235 chain reaction. Two or three neutrons given off, and energy released as heat


U235 FISSION PROCESS
Neutron
Nucleus
Heat
Radiation
Fission Pieces
2 or 3 Neutrons
CHAIN REACTION

The way ahead at last

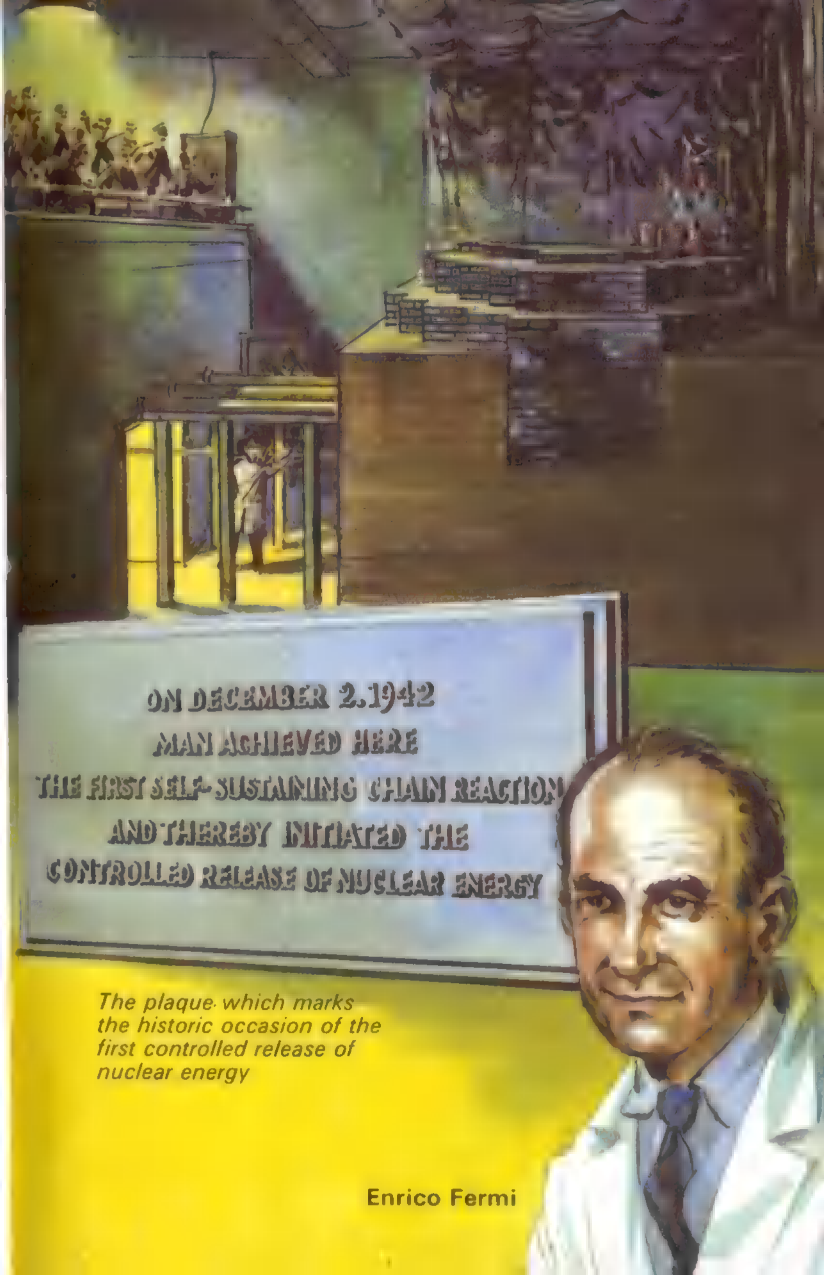
On 2nd December, 1942, Enrico Fermi and his co-workers in Chicago, U.S.A., produced the first controlled nuclear chain reaction in natural uranium, using a device called an *atomic pile*.

The Fermi pile consisted of blocks of graphite in which were placed rods of natural uranium and a few rods of cadmium. The pile was assembled until the exciting moment when a chain reaction was produced. The assembly of enough fuel to enable the fission process to continue is known as the *critical size* and applies to all atomic piles. The graphite blocks were necessary to slow down the neutrons that produce fission so that it could occur in natural uranium. The successful slowing-down process was the 'break-through' needed. The material used for this is known as a *moderator*. Cadmium has the effect of absorbing neutrons, and so by putting it further into, or out of, the pile, some control of the fission process was possible.

The Second World War was in progress at the time when this great event occurred, and this first, controlled chain reaction received no publicity, mainly because the knowledge needed to build an atomic pile was important in the development of the then very secret *atomic bomb*.

However, the successful operation of this atomic pile was a great step forward in man's knowledge of the controlled release of atomic energy.

Scientists in Chicago University watch the first atomic furnace about to operate



The plaque which marks the historic occasion of the first controlled release of nuclear energy

Enrico Fermi

A new power

Nuclear scientists could now begin to see some of the potential uses of this new source of power. For example, heat is produced within the uranium in an atomic pile, and this heat could be used to produce steam to drive turbo-generators and produce electricity. Ships and submarines might be propelled by nuclear engines, perhaps even aeroplanes and space rockets.

The forces that exist in the nucleus of the atom, and which were released continuously in this new device, were millions of times more powerful than any available before. In fact, if the uranium could be completely 'burned' up in an atomic pile, it would release about three million times the energy, weight for weight, than an equivalent chemical reaction. The age-old alchemist's dream of changing the elements was now possible. For instance, an element called *plutonium*–also fissionable–could be produced in an atomic pile by bombarding natural uranium with the fission neutrons. Because the war was still in progress, the scientists' efforts were concentrated on developing a very powerful bomb, its power being based on a very fast fission reaction.

The first atomic bomb was tested in the New Mexico desert, U.S.A., on July 16th, 1945.

Above: An atom bomb test explosion
Below: Peaceful research at Dounreay, Scotland

The atomic age begins

The world suddenly awoke to an awareness of this great new power when an atomic bomb was dropped on Japan, by the U.S.A. on August 6th, 1945. The press announced that the Atomic Age was born.

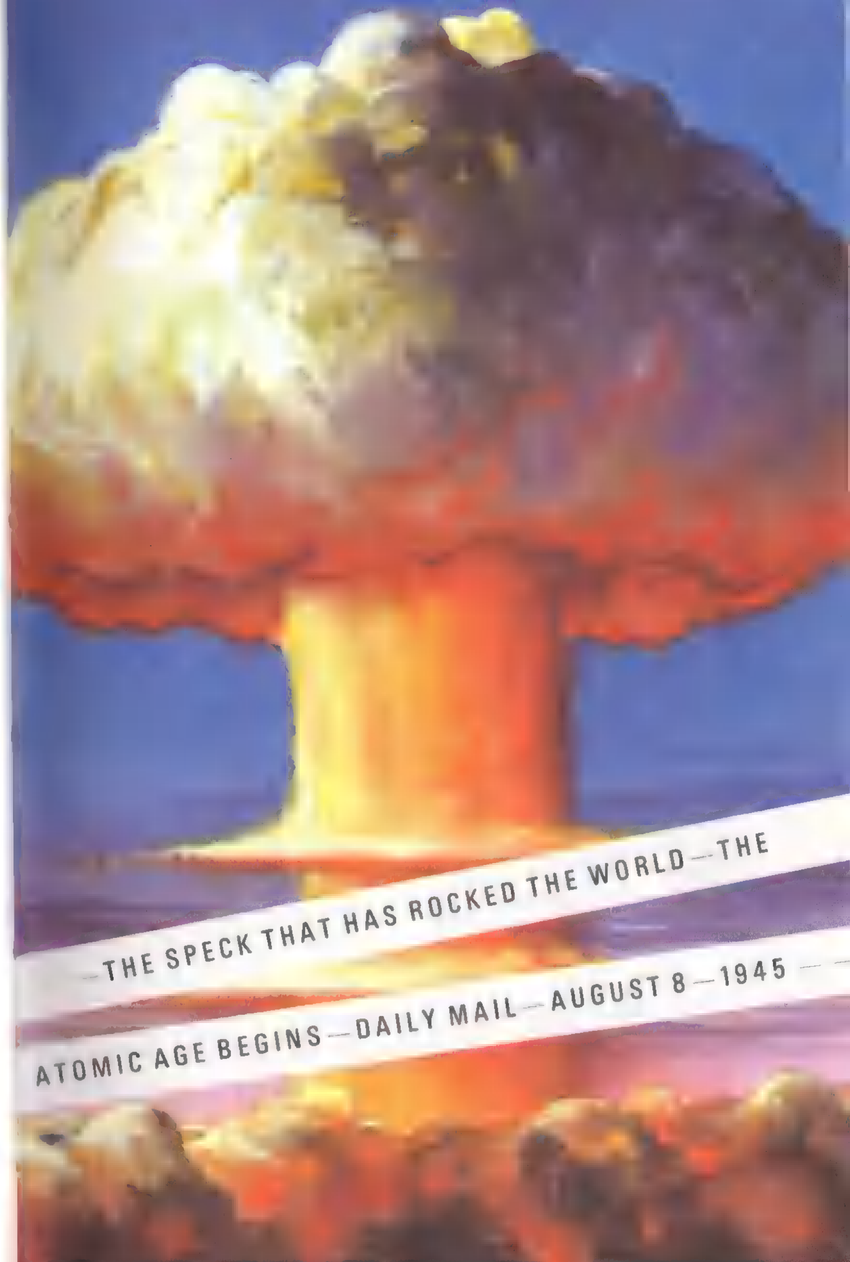
Up to that time, most of the effort devoted to developing this new power had taken place in the U.S.A. and Germany, but it was not long before the United Kingdom, Canada, France and the U.S.S.R. started on their own separate atomic energy programmes.

Uranium, which in the past had mainly been a waste product in mining processes, now became a very important metal. A uranium type 'gold rush' was started in many parts of the world.

To make it work, the atomic bomb needed either very pure U.235 or else the new, man-made metal plutonium. Because it takes a long time to obtain worthwhile amounts of U.235 from the natural uranium, the decision was made to obtain plutonium from the fission process. To produce plutonium in quantity many atomic piles had to be built. Although a big and costly task, experience from the Fermi pile had proved that the fission process could be made to work.

So then came the first breed of atomic piles, those used for producing plutonium and also for experimental purposes.

The world learns of the first atomic bomb explosion in war


—THE SPECK THAT HAS ROCKED THE WORLD—THE
ATOMIC AGE BEGINS—DAILY MAIL—AUGUST 8—1945 — —

The first atomic piles

After the Fermi pile, which could only produce up to two hundred watts of power in the form of heat, many large plutonium-producing piles were built in the U.S.A.

The United Kingdom's first pile was operating in 1947 at Harwell, and was known as G.L.E.E.P.—the Graphite Low Energy Experimental Pile. Eventually many countries had their own piles working either to produce plutonium or else to gain experience with them. Often these first piles were similar in type to the Fermi pile, although new techniques and methods had to be used as they became bigger. The plutonium producing piles were capable of producing millions of watts of power in the form of heat.

Some of the materials used in the early piles would not have stood up to the very high temperatures created within the larger piles. In particular, the fuel rods were clad with aluminium, and this would have melted, so some way of cooling these piles was necessary. This was usually done by forcing either air or water through them.

The fuel rods with the cladding metal became known later on as *fuel elements*, and in the atomic piles built today they are very different from the original Fermi pile fuel rods.

 An artist's impression of some U.K. plutonium piles

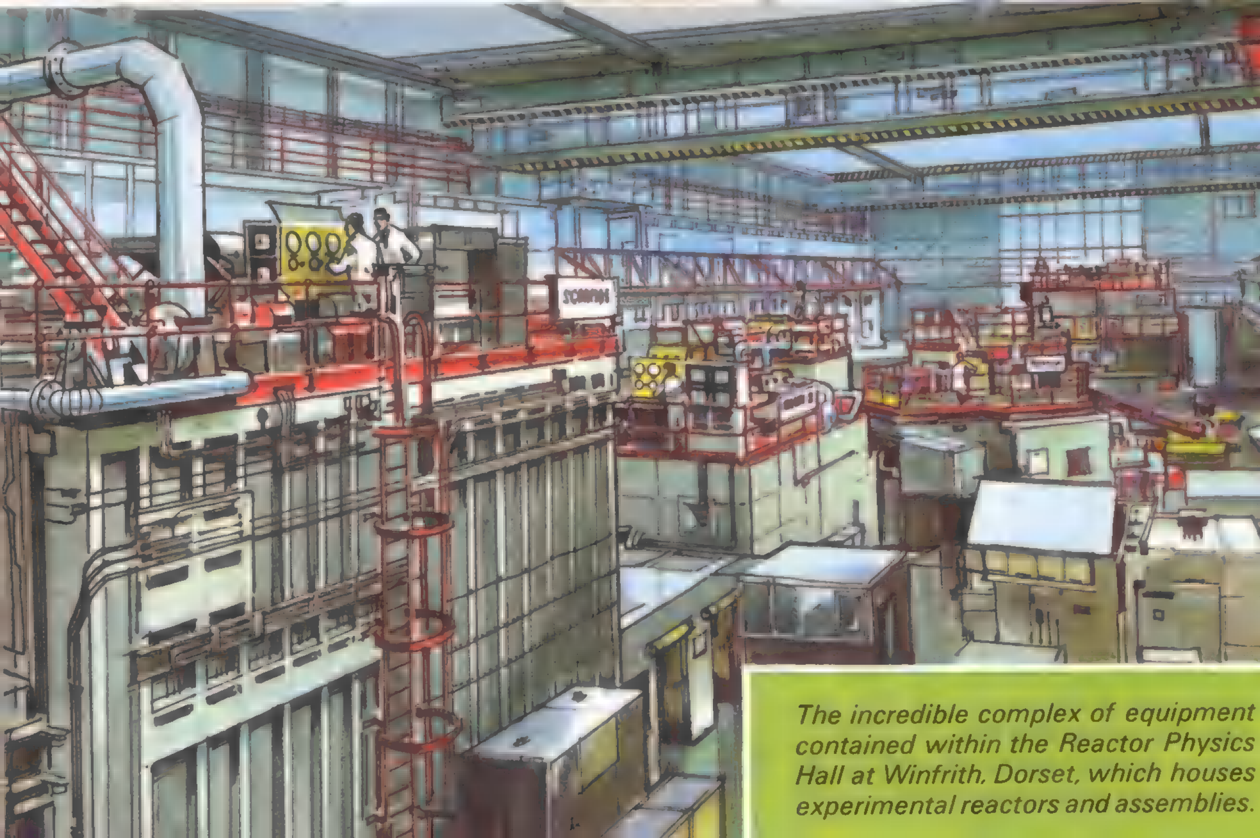
Atomic piles to nuclear reactors

As the nuclear scientists became more experienced in this new science, they produced many ideas about how atomic piles might be made. It has been said that there could be over one thousand possible types, but in practice this number can be reduced to only a few.

The first piles used graphite as the moderating material, the moderator being essential as these early piles used the natural uranium fuel. Other moderating substances are possible, including water and a special type of water, called 'heavy water'. Heavy water is the best moderator but is expensive to produce, and so graphite or normal water were usually used. The water used for moderating can also be used for cooling purposes.

It was soon realised that some gases could be used for cooling, carbon dioxide and helium being among these. Liquid metals such as sodium are also useful, particularly if lots of heat has to be dispersed quickly. It was not long before efforts were made to use this heat which was going to waste out of the piles. The word 'pile' was gradually replaced by *nuclear reactor*, which is now in general use.

Today we have nuclear reactors designed for use in nuclear power stations, using their nuclear heat to produce electricity.



The incredible complex of equipment contained within the Reactor Physics Hall at Winfrith, Dorset, which houses experimental reactors and assemblies.

The first nuclear power stations

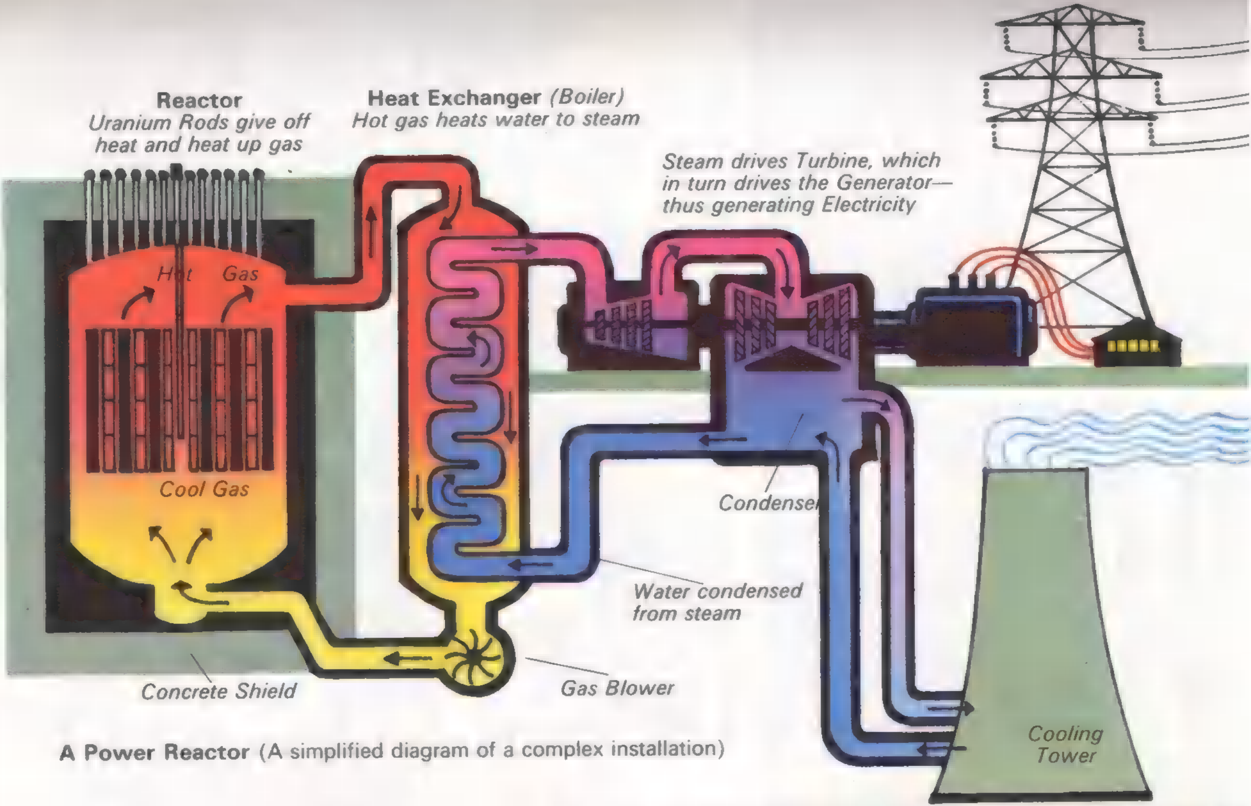
The first electricity ever produced by using the heat from a nuclear reactor was at Idaho, U.S.A., in 1951. The Russians had a small experimental nuclear power station operating in 1954, but the world's first full-scale station was opened in October, 1956, at Calder Hall, Cumberland.

The Calder Hall system consists of two nuclear reactors and power plant, producing about eighty million watts of electrical power. Two of these systems are in operation at Calder Hall, and many more of similar design have since been built. The reactors have a graphite moderator and are fuelled by rods of natural uranium. Carbon dioxide gas cools the reactor, and is also used to transfer the reactor heat to the water in a boiler, where steam is produced to drive the turbo-generators.

Another nuclear reactor system, much used for producing electrical power, is a water-type system where water acts as a moderator and coolant. The fuel required in this system contains a higher than usual content of U.235 in the natural uranium, and is known as 'enriched fuel'. The first station of this type was commissioned in 1957 at Shippingport, Pa., U.S.A.

Although these first nuclear power stations were a great achievement, many improvements were still possible.

A power reactor system



A Power Reactor (A simplified diagram of a complex installation)

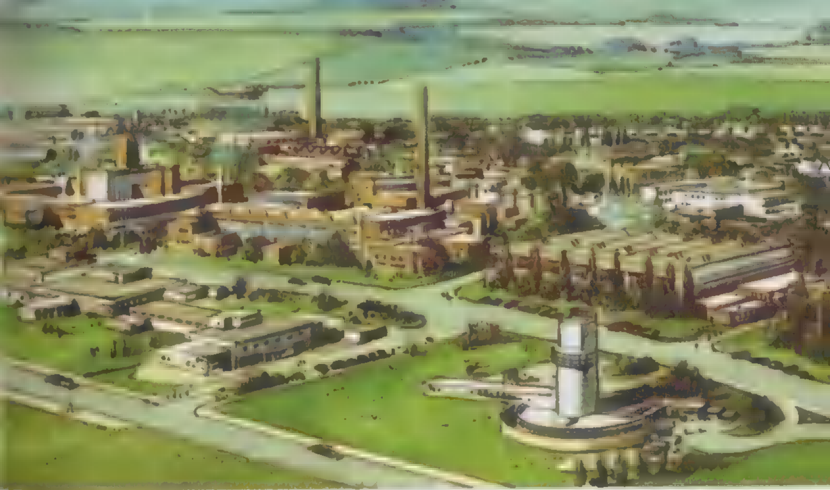
A new industry is formed

To design and build these nuclear power stations required a tremendous effort from all sorts of people. Many countries built up special research organisations and centres. Development of atomic energy in the U.K. started at the end of 1945 within the Ministry of Supply. In 1954 an Atomic Energy Authority, A.E.A., was formed which fostered many research and design centres and places for making fuel and fuel elements. Private firms joined forces to build the nuclear power stations which were ordered by the Electricity Boards, and which in turn needed their own special teams of people.

The development of this new industry included the production of *radioisotopes.* These are substances such as iron, cobalt and iodine which can be made radioactive in a nuclear reactor. Their radioactivity, the emission of various sorts of rays, can be used for many purposes. Hospitals use them for diagnosis and treatment of diseases, and industry, too, has many uses for them.

The early days of any new venture produce the pioneer spirit, and this new industry was no exception.

Above: An aerial view of Harwell
Below: The fuel loading face of B.E.P.O., an early Harwell pile



Computers help in nuclear reactor design

Nuclear research centres now possess many large and efficient computers, which can do very long and complicated calculations so much more quickly than the human brain. Historically these computers are of two types, *digital* and *analogue*. The digital computer is like a gigantic cash register in that it can do calculations in steps, one after another. It is capable of great accuracy and, in particular, is used for reactor physics calculations.

The analogue computer works something like a car speedometer, in that it continuously works out calculations. It is mainly used for studying the behaviour of reactor systems. Both of these computer types are made up of electronic components and may require a large room to accommodate them. Often a model or simulation of a complete Power Station is represented, using these computers. The computer sends signals to a replica control desk, where operators and designers of the power station may make tests without actually using the real power station. Both types of computer have their advantages and disadvantages, and a new type of scientific computer system called the *hybrid computer* is now being produced, and combines the two types into one.

Hybrid computer system

Nuclear power goes to sea

1955 was the year in which the first nuclear-powered submarine—the Nautilus—made its maiden voyage. This submarine was produced in the U.S.A. and since then others have been built. These nuclear-powered submarines are used to carry rockets with nuclear war heads. They can travel at high speeds and only require refuelling about every two years. It is interesting to note that although the *Nautilus* travelled 60,000 miles—of which about a quarter of that distance was under water —the fuel used up was only about the size of a cricket ball.

Many snags had to be overcome before a reactor could be used for such a purpose. For instance, it had to be small and light. The first graphite moderated, natural uranium reactors were too big and heavy, so new systems were designed based mainly upon a water moderated and cooled reactor.

The U.S. Navy also has surface ships propelled by nuclear power, among them being a very large aircraft carrier, called the *Enterprise*.

Only a few nuclear-powered merchant ships have so far been built. The first of these were the Russian ice-breaker Lenin, and the U.S. cargo-passenger liner, n.s. Savannah. No doubt it will not be long before other nuclear-powered merchant ships sail the oceans of the world.

Above: A nuclear-powered cargo-passenger liner
Below: A nuclear-powered submarine

The space age joins the atomic age

With the coming of the Space Age and the very powerful rocket engines required for space rockets, it was natural to consider using nuclear power for these engines. Of course, such nuclear engines must be small and light and also very powerful. The necessary shielding of the nuclear engine, to prevent radiation effects on the crew, presents problems because of its inevitable extra weight.

Experimental nuclear rocket engines have been built and operated successfully on ground test beds. The first of these, called KIWI-A, was operating in the U.S.A. during July, 1959. So far, chemically-fuelled rocket engines have enabled man to land on Earth's nearest neighbour—the Moon. As the exploration of space progresses to the outer planets of the sun or beyond into the universe, it is almost certain that nuclear rocket engines will be needed.

The first planned use of these engines in space is to propel space ships shuttling between Moon and Earth orbits.

Another use for nuclear power in space is for the production of electricity. The U.S.A. have developed a generator, fuelled by plutonium, which has produced power for the operation of instruments used on the Moon during an Apollo mission.

An artist's impression of a future nuclear shuttle in space – loading the fuel tanks

Nuclear power stations get bigger and better

As more nuclear power stations were built, so more and more improvements were made to their design. Higher electrical outputs and better efficiency in operation were possible as engineering problems were solved. The latest of the Calder Hall type stations can now produce over five hundred million watts of electricity per reactor, and is thirty per cent efficient. More advanced nuclear stations of the gas or water cooled types can produce even higher powers and efficiencies.

A further system now being tried out, and referred to as the High Temperature Reactor, H.T.R., should be able to produce about one thousand million watts per reactor and efficiencies of around forty per cent. Many countries are building prototypes of this new system, and one of these, known as 'Dragon', has been built in the U.K. This project has involved the efforts of many European countries.

So far, nuclear power stations have been able to burn up only a small proportion of the uranium fuel used in them. Even so, the latest stations can produce about a hundred thousand times more electricity for a given amount of fuel than a similar fossil-fuelled power station.

An artist's impression of Hinkley Point 'B' – a modern nuclear power station

Small nuclear power plants

Remote localities or countries without much industry need only small power plants of only a few million watts output. Although industry uses vast amounts of power as heat or electricity or both, it often obtains this from small electrical power units or boilers. To find out whether nuclear power can be used economically instead, some small experimental nuclear plants have been built which can produce steam for use in industrial processes or for the generating of electricity.

Small nuclear power plants which can be assembled from transportable units have also been built in the U.S.A. and U.S.S.R. At least one of these units is supplying power for a long-range radar warning post in North America and another is situated at a McMurdo Sound base in the Antarctica. Rather more 'mobile' nuclear power plants have been made which can be mounted on trailers or tracked vehicles. These units can be made operational in a matter of hours and so can rapidly supply electrical power to a disaster area when required.

Another interesting use for a nuclear power plant is in a ship, where it has been inserted to replace the engines. The ship or barge, as it probably should be called, can be towed to remote water inlets where the nuclear plant can provide electricity for the surrounding area.

Top: Packaged nuclear plant being transported by air
Centre: Packed nuclear plant travelling overland
Bottom: A floating nuclear power plant

The nuclear fuel

Although uranium is the main fuel for use in nuclear reactors, both *thorium* and *plutonium* may also be used. If the metal thorium is bombarded with neutrons in a reactor, it produces another form of uranium called U.233 which can also produce a fission reaction. Plutonium is best used as a fuel in what is called a *fast reactor*. This type of reactor, now being developed, requires no moderator as a chain reaction is produced direct from the fast speed neutrons of fission.

Uranium metal is generally obtained from uranium ore which exists in varying quantities all over the world. This ore is usually mined or dug out of the ground. Sometimes gold mines produce uranium as a by-product. The richer uranium ore deposits are found in such countries as Australia, Canada, France, Portugal, South and Central Africa, also the U.S.A. How much useful uranium can be obtained from this ore? This may vary considerably, but if we could fill a bath with uranium ore, we would probably obtain only a bucket or even a cupful of natural uranium from it.

Uranium may also be extracted from *carnotite*, a red and yellow powdered rock found in North America. It is said that the powder was once used by the Red Indian tribes of the area for tribal markings.

Above: Opencast uranium mining
Below: The main countries with uranium ore resources are shown in black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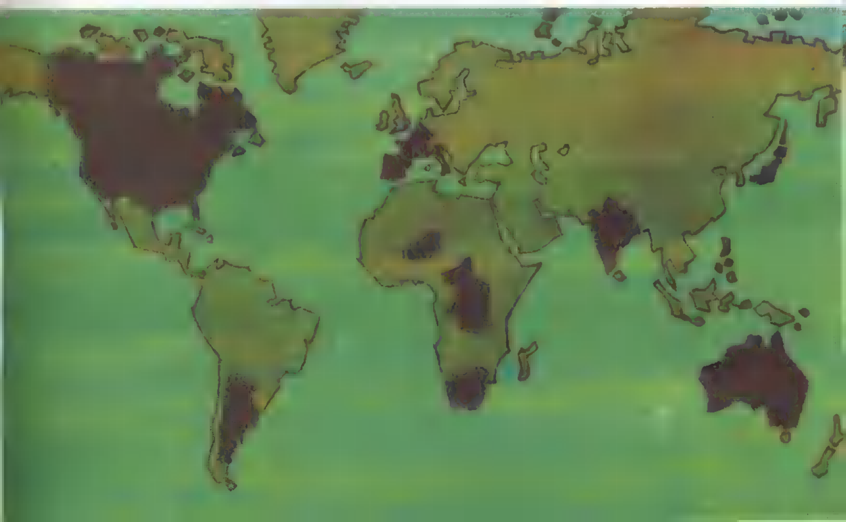
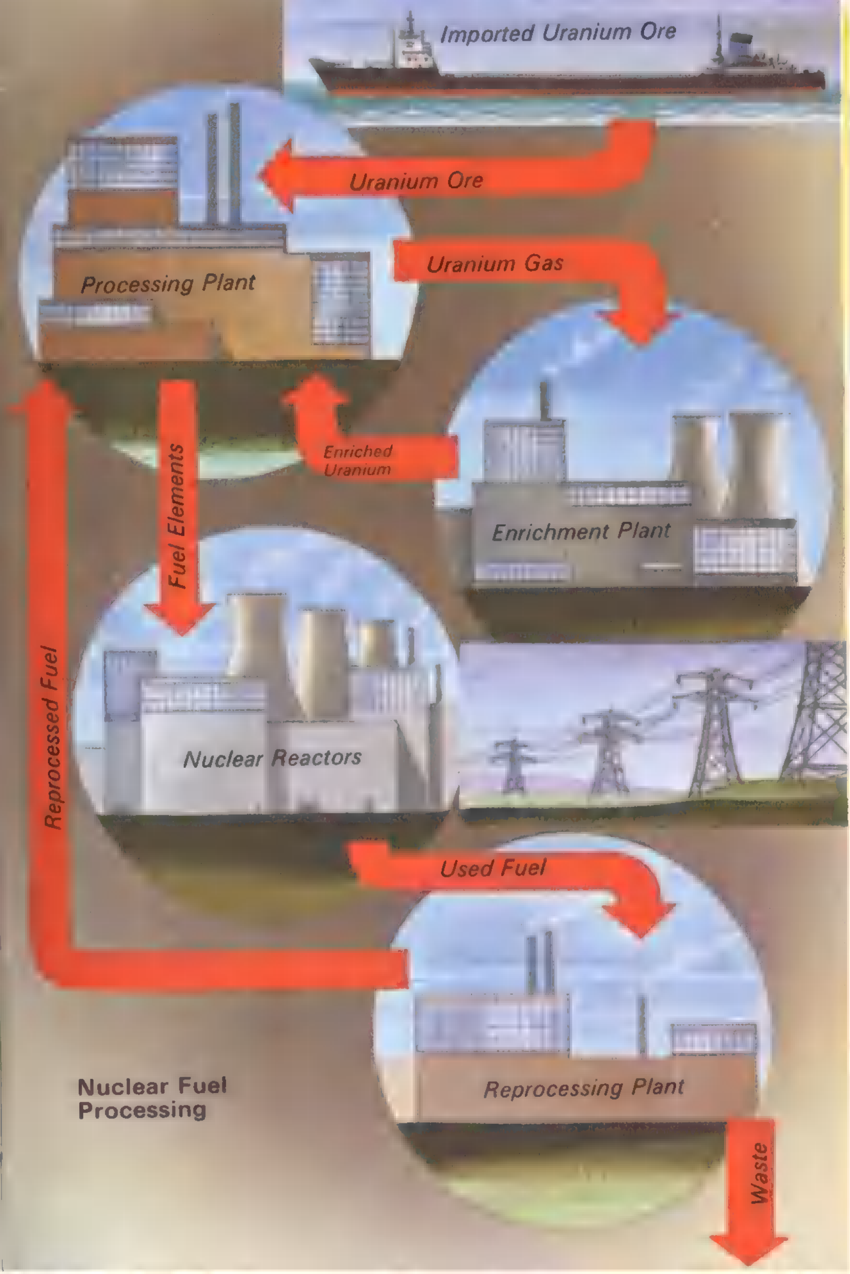


Nuclear fuel processing

We all know that the petrol used to fuel motor cars is the product of refining plants; so is nuclear fuel. The uranium ore has to be sent from where it is mined to an extractor plant where pure, natural uranium is obtained by chemical processes. This natural uranium is then manufactured into fuel elements and taken to the nuclear reactors that require them. If 'enriched fuel' is needed, the natural uranium has to have a greater U.235 content than normal. The U.235 in turn is usually produced by a gas diffusion process in a very costly plant. This plant can produce either pure U.235 or else the enriched mixture of natural uranium and U.235.

When fuel elements have served their useful life in a reactor, they have to be processed to take out any required substances. In a used natural uranium fuel element, this would mean that the depleted (non-burnt) uranium, accumulated plutonium and any radioactive fission products produced within it, would need to be separated. The depleted uranium can be processed again for further use in a nuclear reactor. The plutonium can be used as fuel in fast reactors as they are built.



Nuclear Fuel Processing

The fuel elements

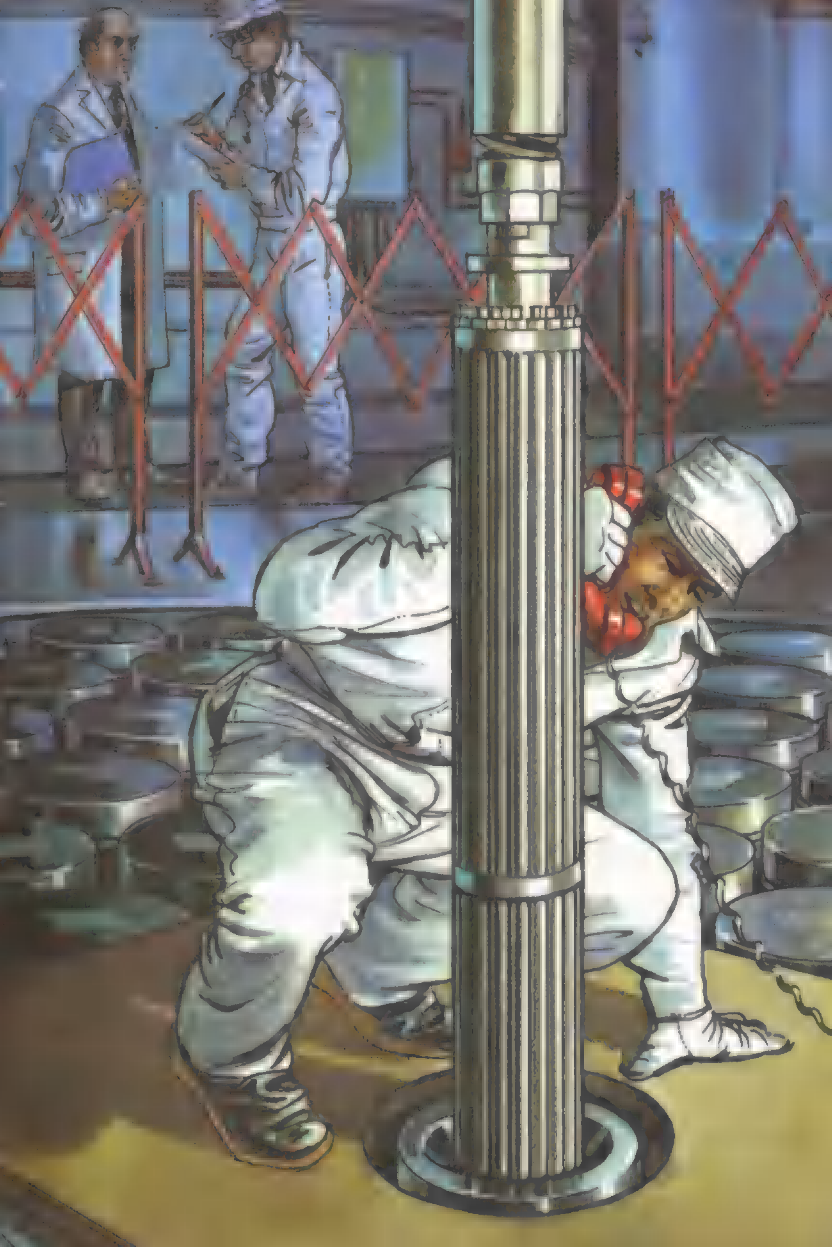
The fuel to be used in a nuclear reactor must be in a form which will enable the heat to be generated within it, and which can also contain the fission products produced. In the first reactors, these *fuel elements* were merely rods of uranium clad in aluminium sheaths. The choice of cladding materials is restricted to those which do not absorb too many neutrons, and which are also capable of withstanding temperature and radiation effects. The Calder Hall type reactors used fuel elements clad in a magnesium alloy. More recent reactors use stainless steel or zirconium as cladding.

The fuel itself has undergone changes. Uranium oxide is now used more than the earlier solid metal uranium rods. One reactor, built in Germany, uses small pebbles of fuel, and the latest high temperature reactors use small particles of fuel bonded together.

The fuel elements of the early piles could be held easily by hand. The complete fuel elements are now often made up of flat plates or round pins of fuel and cladding. When joined together, these can be as large as a lamp post.

It is possible to design reactors which use uranium in a liquid form, but so far this type has not been used for nuclear-powered generators.

The initial loading of a fuel element into a nuclear reactor



Handling and transporting the fuel elements

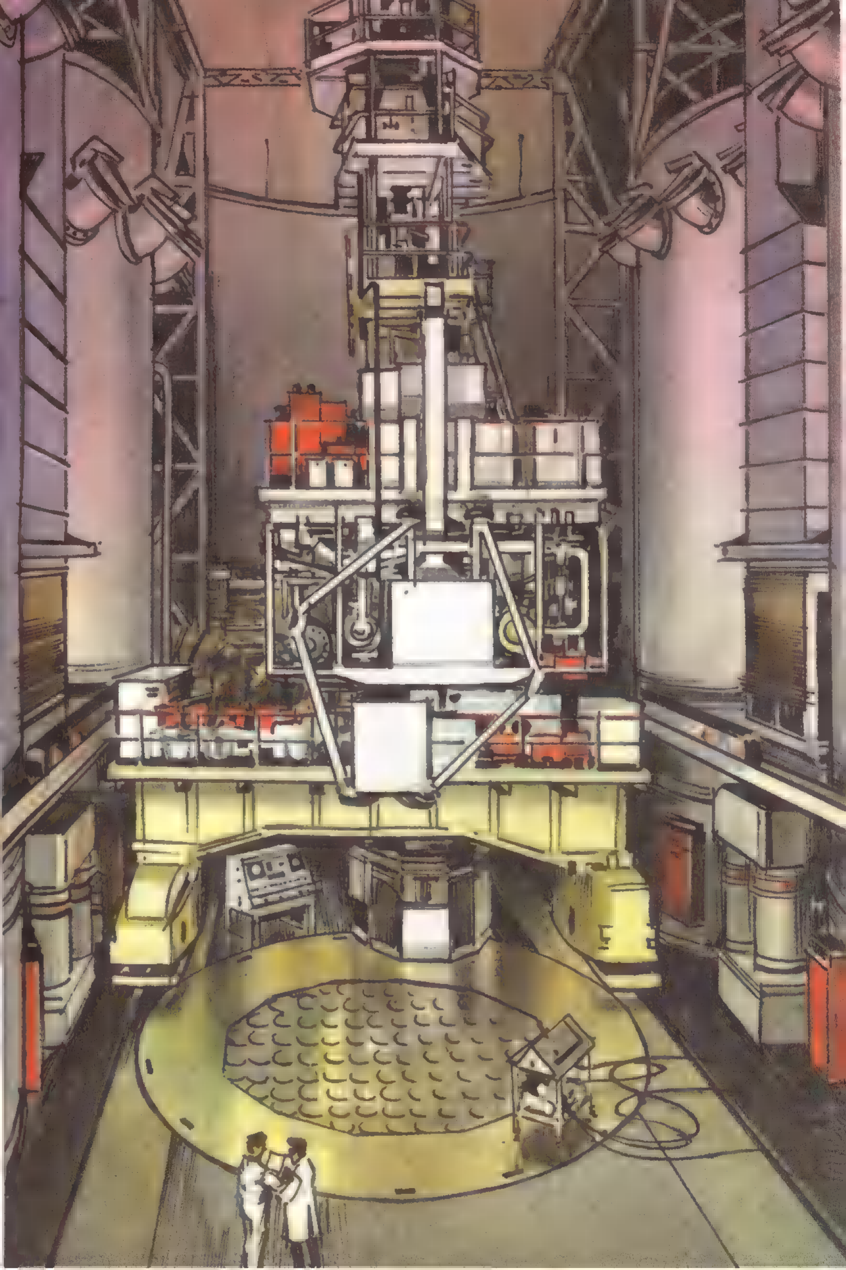
New fuel elements are only slightly radioactive, but are highly radioactive when they have been in a reactor for a long time. To handle them under these highly active conditions requires special equipment, and usually a machine called a refuelling or discharge machine is used. This machine is of lead and metal construction, and can grab the fuel elements and put them in or out of the reactor under the control of a human operator some distance away.

When taken out of the reactor, the used fuel elements are hot as well as radioactive. They are taken by the machine to be stored where they can cool down and become less active. Often a tank or pond of water is used to store these used fuel elements. The water cools them and also acts as a protective shield against the radioactivity.

When the fuel elements are safe to move, they are put into special containers and sent to a processing plant.

The Atomic Energy Authority uses a specially converted ship, called the Stream Fisher, which can transport used fuel elements from overseas to the U.K. processing plant.

A refuelling machine above a nuclear reactor



Future nuclear power stations

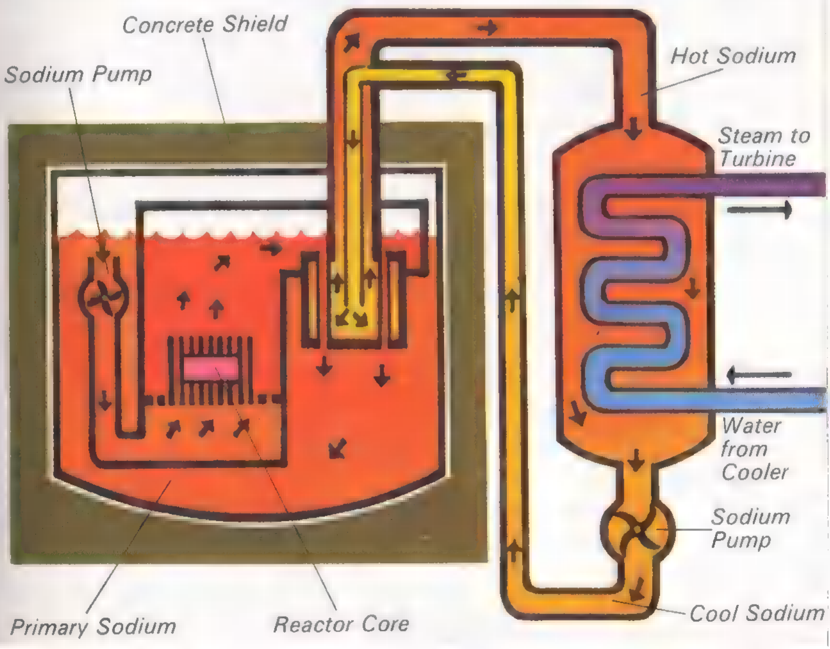
Nuclear reactors have advanced a long way from the first Fermi pile to the present high-powered reactors. Further advances are possible in the design and construction of the reactor and its use.

At present, nuclear power plants usually produce steam to drive steam turbines, but other methods are possible. For example, high temperature, gas-cooled reactors may drive gas turbines to convert the reactor heat to electricity. It may eventually be possible to produce electricity more directly from the reactor heat, without using moving machinery. So far this can only be done on a small scale and at low efficiencies.

Nuclear reactors are being built to study the use of thorium and plutonium as nuclear fuels, also fuels in a liquid or even molten salt form.

A reactor system which holds much promise for the future is the *fast breeder*. Using the fast speed neutrons to continue the fission process, this system is able to 'breed' more useful fuel than it consumes. Plutonium is produced from the natural uranium placed in the reactor and the plutonium itself can then be used in that reactor or other breeder reactors.

Above: The prototype fast reactor at Dounreay
Below: A simplified diagram of the reactor


Concrete Shield
Sodium Pump
Hot Sodium
Steam to Turbine
Water from Cooler
Sodium Pump
Cool Sodium
Primary Sodium
Reactor Core

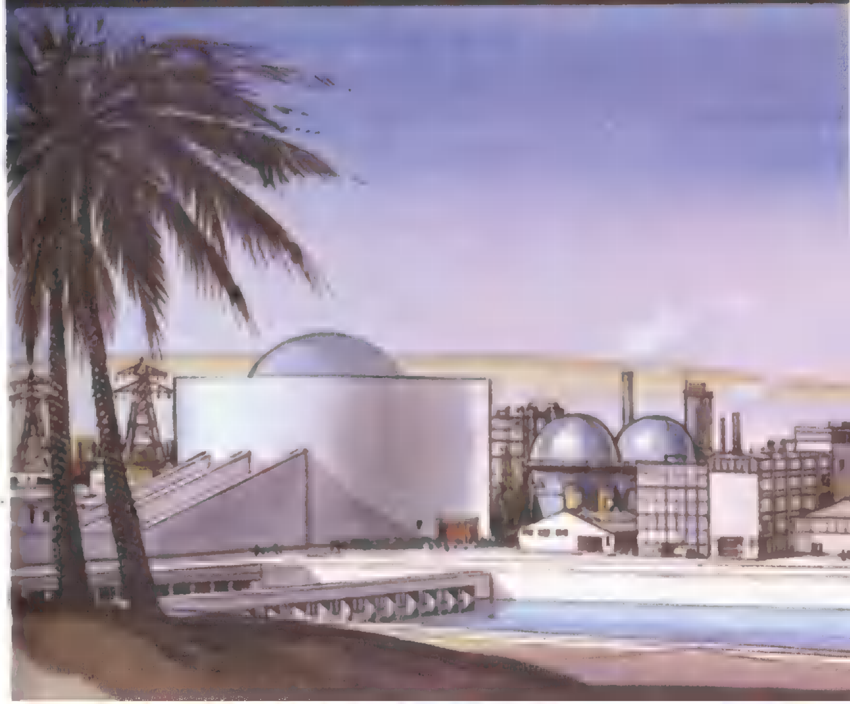
Further possibilities

One day it may be possible to have plenty of fresh water, and grow an abundance of food in the deserts of the world, particularly if they are near the sea. This could be done by using the heat from nuclear reactors in a desalination process to convert sea water into fresh water. The heat could also be used to produce electricity, as in the nuclear power stations. By using this water and electricity, special ‘food farms’ could produce food for the growing population of the world.

Transportation of passengers and cargoes across the continents and oceans of the world is a big and growing business. Perhaps one day cargo and maybe even passenger submarines propelled by nuclear engines, will travel the depths of the oceans. Maybe hovercraft, if ever used for ocean crossings, could also be propelled by nuclear engines. Nuclear-powered ‘air tugs’ shuttling their pay loads across the upper atmosphere are yet another possibility, although normal aircraft would be required to feed and return their cargoes.

It may well be that one day undersea food farms will be developed and much more underwater exploration done. Such projects will need huge amounts of power, which nuclear reactors could supply.

Above: Ancient Greek seamen distilling sea water for drinking. Below: An artist's impression of an agro-industrial complex in a desert area

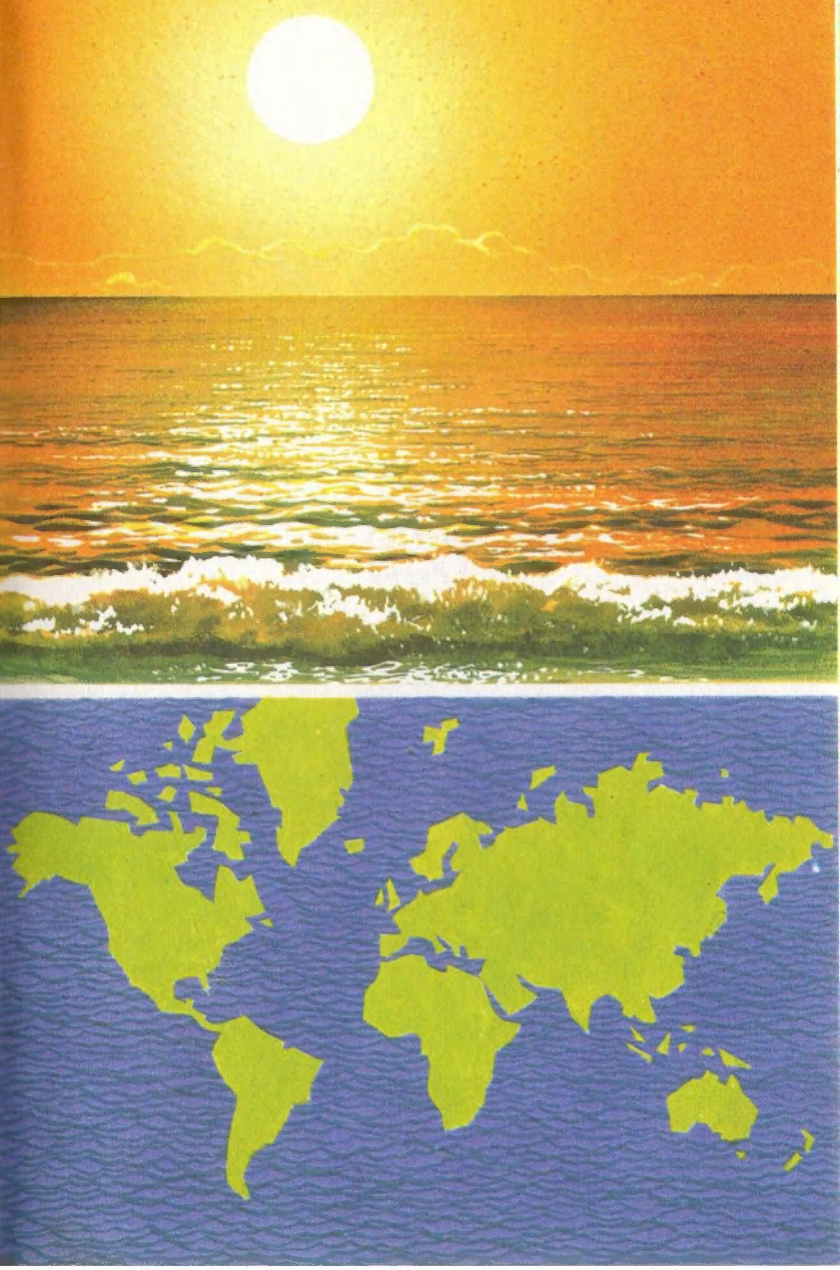


Power for the future

Nuclear power by the fission process will always be with us, for we can now produce power from the great forces within the nucleus of the atom. We may well ask ourselves if there are forces even more powerful than these. The growing knowledge about the universe suggests there are fantastic forces at work in the birth and death of some stars. Not enough is known about these forces, but we do know the source of power giving the sun its energy. Known as *fusion*, when light atomic matter is forced together to form heavier matter, this process uses the same nuclear forces as in fission. What makes the process so interesting is that the most promising fuel for a fusion plant on earth is *deuterium*, a form of hydrogen which can be extracted from normal sea water. There is a tremendous amount of sea water on this planet waiting to be used. So far scientists are unable to produce the fusion process in a controlled manner, mainly because we cannot heat up the fuel to the required fifty to a hundred million degrees for long enough.

As our supplies of the fossil fuels, and of uranium, become used up, it will doubtless be necessary to find another source of power for this power-hungry world. Fusion may well be the answer if the present problems can be solved.

Above: The sun's energy is obtained from fusion. A possible fuel for a fusion plant could be obtained from sea water
Below: Nearly three-quarters of our planet's surface is covered by sea water



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